individual gas component at the selected temperature for a period of at least about one minute;

(b) determining the electrical response value of each chemo/electro-active material upon exposure of the array to the gas mixture; and

(c) performing an analysis of the individual gas component from the electrical response values.

Description of the Drawings

Figure 1 depicts the sensor array concept.

Figure 2 is a schematic of the pattern of interdigitated electrodes overlaid with the dielectric overlayer, forming sixteen blank wells.

Figure 3 depicts the electrode pattern, dielectric pattern, and sensor material pattern used in preparing array chips for measurement.

Detailed Description of the Invention

The present invention is a method and apparatus for directly sensing one or more analyte gases in multi-component gas systems under variable temperature conditions. By "directly sensing" is meant that an array of gas-sensing materials will be exposed to a mixture of gases that constitutes a multi-component gas system, such as in a stream of flowing gases. The array may be situated within the gas mixture, and more particularly within the source of the gas mixture, if desired. Alternatively, the array may reside in a chamber to which the gas mixture is directed from its source at another location. The gas mixture may be inserted in and removed from the chamber by piping, conduits or any other suitable gas transmission equipment.

A response may be obtained upon exposure of the gas-sensing materials to the multi-component gas mixture, and the response will be a function of the concentrations of one or more of the analyte gases themselves in the gas mixture. The sensor materials will be exposed substantially simultaneously to each of the analyte gases, and the analyte gas(es) do not have

to be physically separated from the multi-component gas mixture in order to be analyzed. This invention can be used, for example, to detect and/or measure the concentrations of combustion gases, such as oxygen, carbon monoxide, nitrogen oxides, hydrocarbons such as butane, CO_2, H_2S, sulfur dioxide, halogens, hydrogen, water vaopr and ammonia, at variable temperatures in automobile emissions.

This invention is therefore useful at the higher temperatures found in automotive emission systems, typically in the range of from about 400°C to about 1000°C. In addition there are a variety of other combustion processes for which this invention could be applied, including diesel engines and home heating. These applications require the detection of gases such as nitrogen oxides, ammonia, carbon monoxide, hydrocarbons and oxygen at the ppm to per cent levels, typically in a highly corrosive environment. This invention is also useful for detecting gases in other gas systems such as those found in manufacturing processes, waste streams, and environmental monitoring; or in systems in which odor detection important and/or which are at lower temperature, such as in the medical, agricultural or food and beverage industries.

This invention utilizes an array of sensing materials to analyze the components of a gas system to, for example, detect the presence of and/or calculate the concentration of one or more individual analyte gas components in the system. By "array" is meant at least two different materials that are spatially separated, as shown for example in Fig. 1. The array may contain, for example, 3, 4, 5, 6, 8, 10 or 12, or other desirable numbers of, gas-sensing materials. It is preferred that there be provided at least one sensor material for each of the individual gases in the mixture to be analyzed. Preferably the mole percentages of the major components of each gas-sensing material differs from that of each of the others.

The sensing materials used are chemo/electro-active materials. A "chemo/electro-active material" is a material that has an electrical response to at least one particular gas. Some metal oxide semiconducting materials, mixtures thereof, or mixtures of metal oxide semiconductors with other inorganic compounds are chemo/electro-active, and are particularly useful in this invention. Each of the various chemo/electro-active materials used herein preferably exhibits an electrically-detectable response of a different kind and/or extent upon exposure to an analyte gas of interest than each of the other chemo/electro-active materials. As a result, an array of appropriately chosen chemo/electro-active materials can be used to analyze a multi-component gas mixture, such as by interacting with an analyte gas, sensing an analyte gas, or determining the presence and/or concentration of one or more analyte gases in a gas stream, despite the presence of interfering gases that are not of interest.

This invention is useful for detecting those gases that are expected to be present in the gas stream. For example, in a combustion process, gases that are expected to be present include oxygen, nitrogen oxides, carbon monoxide, hydrocarbons, ammonia or hydrogen sulfide. Other gases of interest may include alcohol vapors, solvent vapors, hydrogen, water vapor, and those deriving from saturated and unsaturated hydrocarbons, ethers, ketones, aldehydes, carbonyls, biomolecules and microorganisms.

The measurement of gas concentrations using these sensor materials can be based on a change in an electrical property, such as AC impedance, of each of the materials upon exposure of the materials to a mixture containing one or more analyte gases. Analysis of a gas mixture can also be performed in terms of extent of change in other electrical properties of the sensor materials, such as capacitance, voltage, current